Bidirectional Reflectance Measurements of Silicon Microstructures

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Surface modifications have great potential of selective emission and absorption for applications in space and energy conversion devices. Pattern-induced radiative property change is an important issue in the manufacturing and diagnostics of microelectronic devices. This work investigates the radiative properties, especially the polarized bidirectional reflectance of patterned silicon wafers, at several laser wavelengths from the visible to the near infrared using a recently developed bidirectional scatterometer. Both 1-D and 2-D periodically patterned microstructures will be manufactured using silicon microfabrication technology. These microstructures are formed with anisotropic etching of the silicon through a patterned silicon nitride hard mask, and have a lateral periodicity of 1-10 μm, have an aspect ratio (height/width) as high as 10. The effects of aspect ratio, groove depth, doping level, and process-induced variations will be studied. Surface topography will be characterized using a stylus profilometer, optical interference microscope, and atomic force microscope. Theoretical predictions from rigorous electromagnetic-wave theory and from simplified models (such as geometric optics and statistical optics) will be compared with the experimental results.

Recent studies have shown that a strong coherent thermal radiation exists, both directionally and angularly, in periodic microcavities. The origin of coherent thermal and optical radiation is believed to lie in the diffraction of surface-phonon polaritons and surface plasmons by the grating. Detailed bidirectional reflectance characterization of periodic microstructures can help us gain a better understanding of coherent radiation effects and increase our ability to design functional smart structures and composite surfaces.

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